TITLE: Channel-Switching add/Drop Multiplexer With Tunable Fiber Bragg Grating Based on the Cantilever Beam

Channel-switching add/drop multiplexer with tunable fiber Bragg grating based on the cantilever beam

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ABSTRACT

A channel-switching add/drop multiplexer with tunable fiber grating tuned by cantilever beam is proposed and experimentally demonstrated. The device consists of two 3dB couplers and a fiber Bragg grating with 99% peak reflectivity at 1557.86nm and a 0.2nm bandwidth. The grating is firmly clung on an organic glass cantilever beam and we can continuously tune the reflectivity wavelength through tuning the cantilever beam manually. The no-chirped linearly tuning range is about 6.1nm, which may permit 7 channels with channel spacing of 0.8nm (100GHz) to insert or drop signal. A broadband light source and a 4-wavelength all fiber laser are used to test its capability in experiment. The adjacent channel isolation is not less than 23dB. The device shows good performance, but suffers from a high insertion loss.

Keywords: Optical add/drop multiplexer, fiber Bragg grating, linearly tuning, cantilever beam.

1. INTRODUCTION

Optical fiber gratings have perfect spectral characteristics for multiplexing and demultiplexing in a wavelength division multiplexing system (WDM), since they are inherently low loss, spectrally extremely selective, and potentially low cost[1]. The ability to add and drop wavelengths from WDM is a key function. Accomplishing this task optically, rather than electrically, is an exciting challenge for photonics lightwave system developers. Optical add/drop multiplexers (OADM), in the simplest of terms, add and drop wavelengths at intermediate points in a communication networks.

There has been a large amount of work recently on the construction of OADM using fiber Bragg grating and strongly coupled fiber coupler[2,3]. Up to now, many schemes have been put forward. Classified by the operation principle, these optical add/drop multiplexer can basically be categorized into two types, namely, interference type[4-6] and non-interference type[7-11]. For exampe, all-fiber Mach-Zehnder interferometer is an interferometric type OADM which has been researched deeply[2]. In order to show proper performance, these devices have to be fine tuned and maintained throughout the device lifetime, which is not desirable. Moreover, the two gratings have to be identical and their path lengths to the couplers must match. This cause many difficulties in the fabrication of these devices. Recently, a few new scheme of OADM based on wavelength grating router, optical switches and arrayed grating waveguide are also been proposed[12-17], however, these devices is very expensive and not easy to fabricate. A tunable add/drop filter, giving access to all frequency components of the WDM signals is needed to provide flexibility in DWDM ring architecture and several ways have been put forward. In this paper, a channel-switching add/drop multiplexer with tunable fiber grating tuned by cantilever beam is proposed and experimentally demonstrated. The tuning principle of fiber Bragg grating is a mechanic tuning method which is very easy to realize.

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2. THE CONFIGURATION and OPERATION PRINCIPLE OF OADM

Fig.1 shows a schematic diagram of the proposed channel-switching OADM device. The OADM is composed of two 3dB couplers and a tunable fiber Bragg grating. These two remnant ports of the two 3dB couplers are disposed to diminish the reflection light which will give rise to the decline of its capability. The basic principle of it is as follows: a stream of several wavelength (for example, $\lambda_1, \lambda_2, \lambda_3, \lambda_4$) signals are launched into the input port of the OADM. Assuming the tunable fiber Bragg grating resonant wavelength is λ_2, light at wavelength λ_2 will be reflected by the fiber Bragg grating and emerge in the drop port. The remaining light ($\lambda_1, \lambda_3, \lambda_4$) not dropped by the fiber Bragg grating will pass through and emerge in the output port together with the light added through the add port.

Fig.2 shows the configuration of cantilever beam tuning unit. The fiber Bragg grating is photoimprinted with KrF excimer laser and the phase mask technology. The fiber Bragg grating is firmly stuck on a cantilever beam that is made of organic glass with epoxy resin. Through tuning the cantilever beam with the precision adjuster, we can tune the resonant wavelength of fiber Bragg grating consecutively. The no-chirped linearly tuning range of fiber Bragg grating is about 6.1nm in our experiment, which may permit 7 channels with channel spacing of 0.8nm (100GHz) to insert or drop.

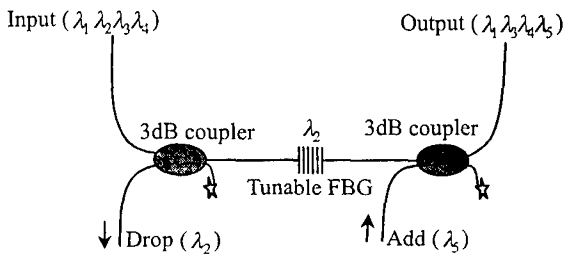

Fig.1 Schematic diagram of channel switching OADM

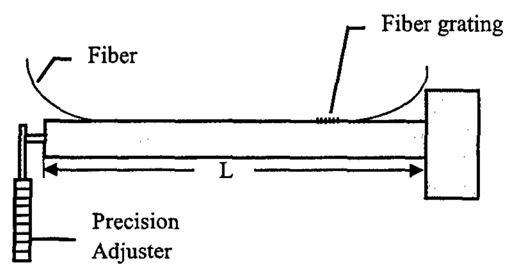

Fig.2 The configuration of fiber Bragg grating tuning unit

3. EXPERIMENTAL RESULTS and DISCUSSION

3.1. The experimental results using the broadband light source as the input signals

A FBG with 99% peak reflectivity at 1557.86nm and a 0.2nm bandwidth is used in this experiment. We use a broadband light source made by ourselves as the input signals to test the capability of OADM. The OADM is linked with optical isolator at both sides in order to diminish the reflective light before it is used in the experiment. The spectral response of the device is shown in Fig.3, which is measured by a commercial Optical Spectrum Analyzer (Advantest Q8383) with a resolution 0.1nm. The output signals of the broadband light source are launched into the input port, the power transferred to the drop port, add port and output port is shown in Fig 3, (b), (c), (d), respectively. Fig.3 (a) is Power spectrum of the broadband light source. Please note that all the curves are not corrected by the reference curve. In experiment, we also find that the groove in add port spectrum will be bigger if we do not dispose the remnant port of couplers or we do not use an isolator at the output port. From the add port spectrum, it is easy to see that the OADM has very good unidirectional and isolation. We can use 3dB coupler to demultiplex the input multiple signals and utilize the fiber Bragg grating to select corresponding wavelength to drop. In the following part, we will test the capacity of this device.

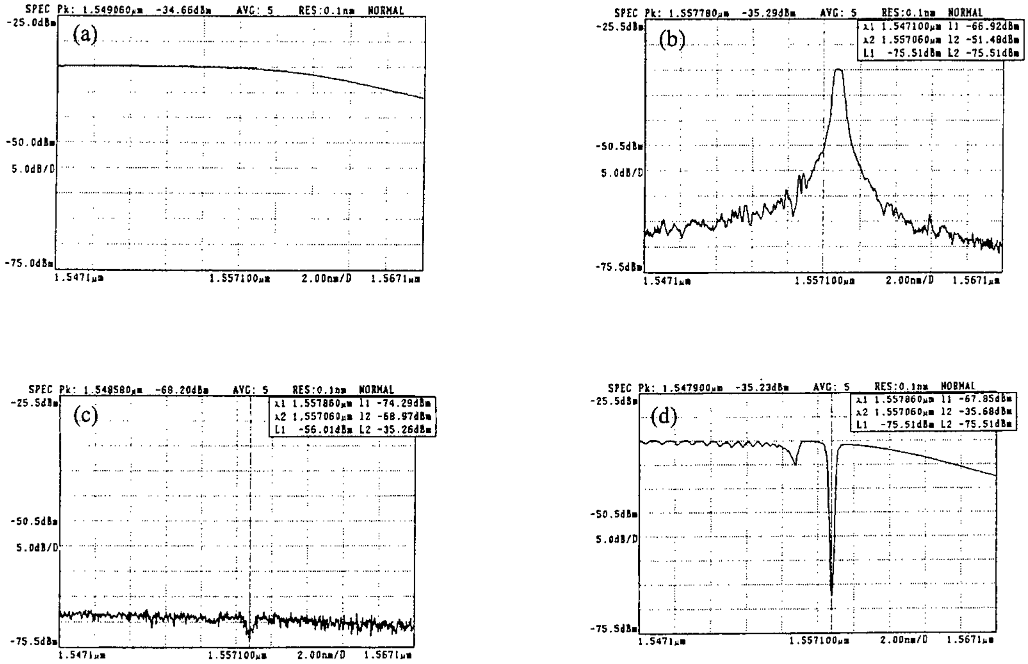

Fig.3 (a) Power spectrum of broadband light source. (b) Power spectrum of the Drop port. (c) Power spectrum of the add port. (d) Power spectrum of the output port.

3.2. The experimental results using a 4-wavelength all fiber laser as the input signals

To investigate the feasible of this OADM, one set of four channel signals created by a 4-wavelength all fiber laser with 0.8nm channel spacing in the 1555nm band are used as signal source. The spectrum of 4-wavelength all fiber laser is shown in fig.4 and the wavelengths are 1555.8nm, 1556.6nm, 1557.4, 1558.2nm, respectively. We have accomplished a 100km, 4 $\times$2.5GHz WDM transmission experiment. In this experiment, we use the OADM to drop relevant signal that has been transferred 100km. Fig.5 (a), (b) are the signal spectra dropped when the fiber Bragg grating is tuned to 1555.84nm, 1557.4nm, respectively. The three small spectral components contaminating the dropped signal are due to the crosstalk. The interchannel isolation in fig.5 (a) is about 29dB and 23dB in fig.5 (b). This OADM can demultiplex other channel signals by tuning the fiber Bragg grating using the cantilever beam method.

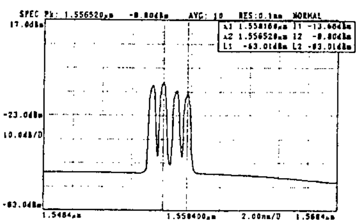

Fig.4 4-wavelength all fiber laser

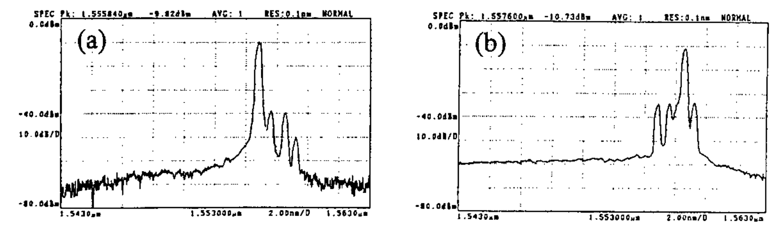

Fig.5 (a) The dropped signal at 1555.84nm. (b) The dropped signal at 1557.4nm

The crosstalk level of the OADM shows that the OADM can basically meet the practical need of WDM ring network. Further reduction in the crosstalk level for upgrading the system performance is possible by improving the fiber Bragg

grating reflectivity. Over two months we observed no decline in the devices performance. Due to using two 3dB optical couplers, so the transmission loss is very high. This is its main disadvantage. The loss of signals can be counteracted by EDFA. in fact, we use two EDFA in our transmission system to magnify these signals. If we use the optical circulators instead of the 3dB optical couplers, the performance of the OADM will improve.

4. CONCLUSION

In summary, a simple structure, linear tuning, high channel isolation, low channel crosstalk, low cost scheme of OADM is proposed. It performs perfect with a channel wavelength selectivity. Its high insertion loss will restrict the improvement of system performance, however, it provide us with one low cost, precision tuning, reliable choice. The low cost makes it very attractive in WDM optical networks. OADM makes the WDM optical networks flexible and it allows people to add or drop signals they need at the node expediently.

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